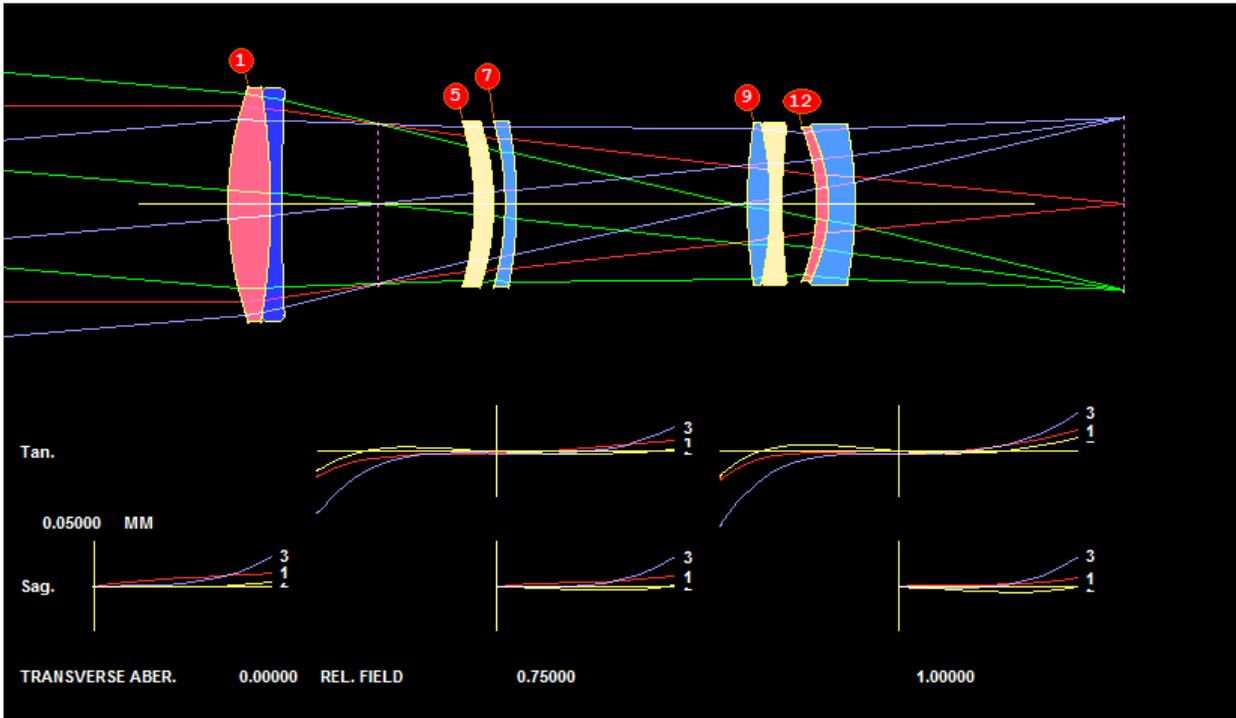


## Lesson 44: Why doesn't SYNOPSIS use "Coordinate Breaks"?

Users of Zemax™ know all too well the hassle of inserting a dummy surface in their lens wherever something is to be tilted or decentered. That program has few options for that purpose.

SYNOPSIS, on the other hand, has no less than six protocols for describing tilts and decenters (TDC), only one of which involves a dummy surface. (And that geometry can also be specified without that extra surface, if you prefer.) Let us give some examples. Here is a typical camera lens with eight elements:

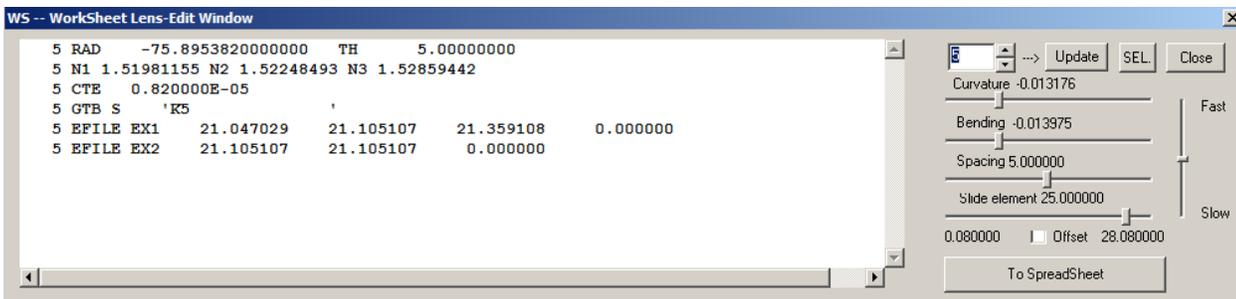


Suppose you want to see the effect on the image of a centration error on the third element. Simple. You can use a CHG file, which is a very quick way for an expert to change the lens. Let us assign a centering error of 50 um on that element. Here is the CHG file:

```
CHG
5 DECENTER 0 .05 0 2
END
```

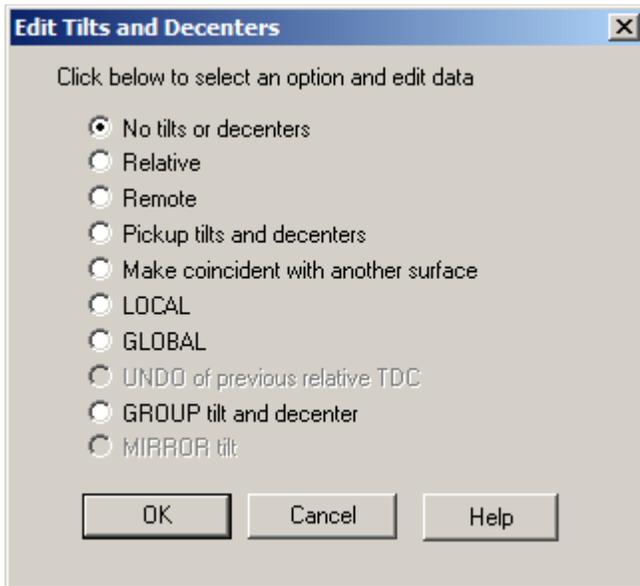
That's it. Surface 5 is now decentered in (X,Y,Z) by the three arguments, and two surfaces are involved. So surface 7 stays where it was. No dummy is required, and the reverse is automatic. You can do the same thing with the Worksheet™ (WS). In the

SketchPAD™ display, click the Worksheet button, , and then click the lens picture at surface 5. The Worksheet Lens-Edit Window now shows the input data that describe surface 5 (with no decenter yet):

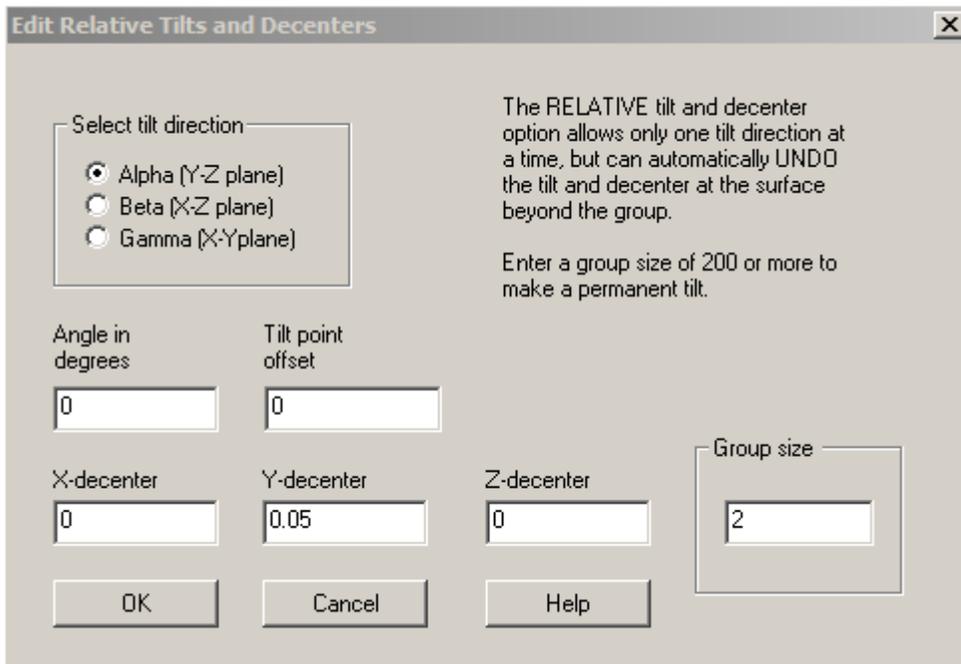


Click in the edit pane and type **5 DEC 0 .05 0 2**; then click the Update button. That's it. And if you don't remember the syntax?

Simple. When the WorkSheet is open at surface 5, click the Tilt Dialog button on the WorkSheet toolbar, . Now you see a list of the possibilities in SYNOPSIS.



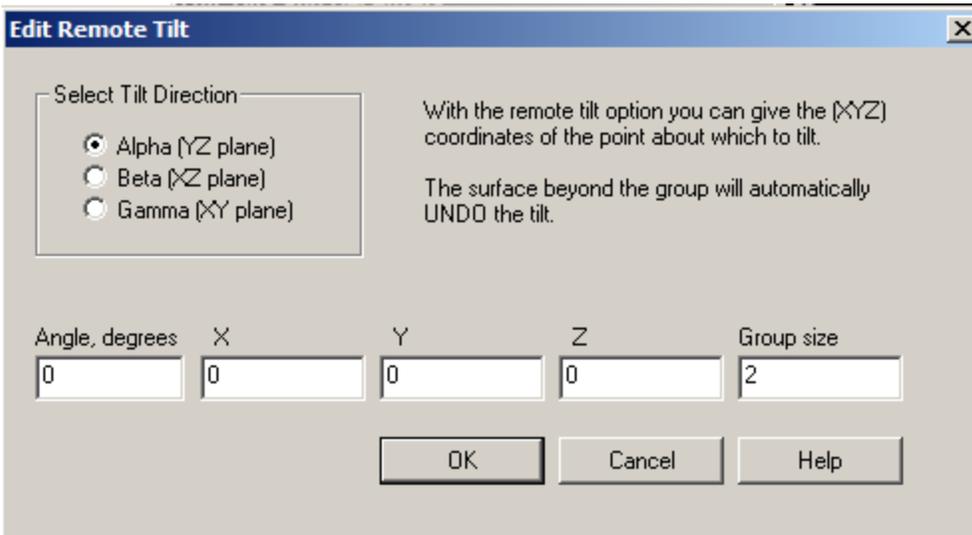
At the moment, there are no tilts on surface 5, so click the **Relative** button. You get a choice of a tilt direction, angle, offset point, and decenter data. Enter 0.05 in the Y-decenter box, specify a group size of 2, and click OK twice.



Now that element is again decentered. Again there is no crummy dummy required!

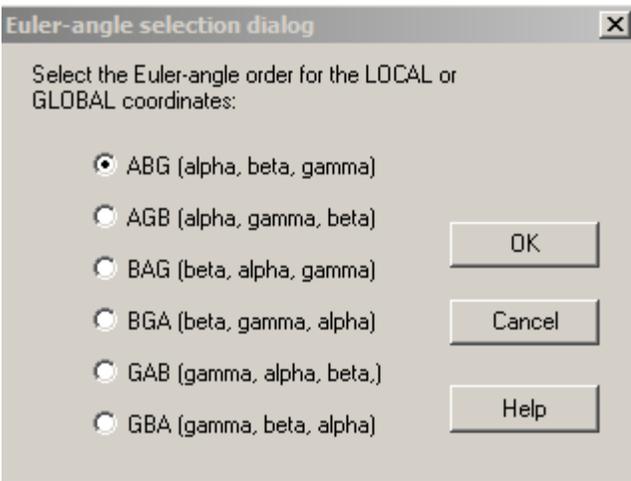
The option you selected, called the **Relative** option, allows you to input a single tilt direction plus a decenter, and the reverse tilt or decenter following the group is automatic. This makes that option quick and friendly.

But we're not done. Suppose you want to tilt an element about a point located at an arbitrary (X,Y,Z) location. That's what the next option on the dialog, the **Remote Tilt**, does. Clicking that option opens a dialog where you specify the location of that point.



The other options should be easy to understand: have a surface pick up the TDC of an earlier surface, or make it coincident with another.

Now things get fancy. The **Local** option opens a dialog where you give the Euler order of three tilt angles



When you make your selection and go back to the WorkSheet, the program creates the input lines needed to specify the local position and angles of surface 5. Simply edit the numbers in the edit pane and you're there. The position data are (X,Y,Z), and the angles are (Alpha,Beta,Gamma).

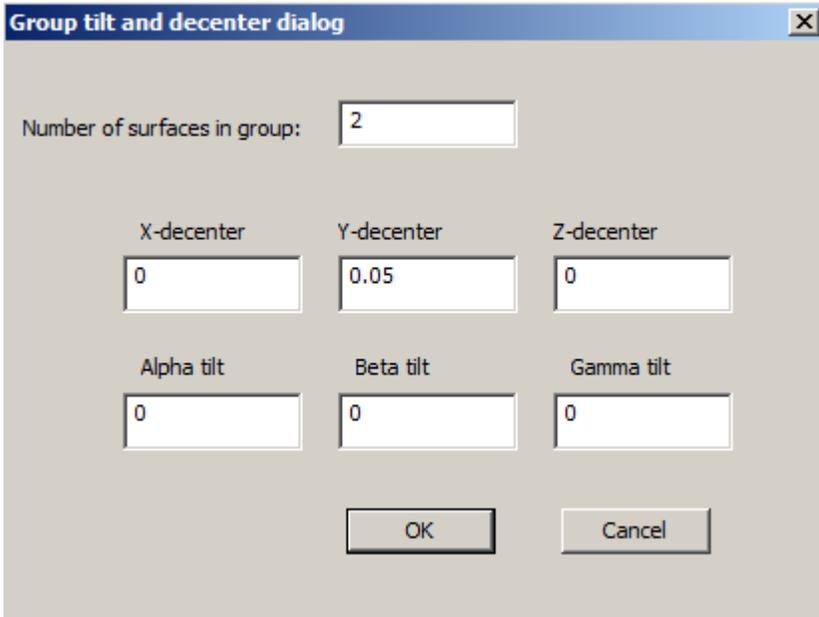
```

5 GTB S      'K5      '
5 LOC POS      0.00000000      0.00000000      25.00000000
5 LOC ANG      0.00000000      0.00000000      0.00000000

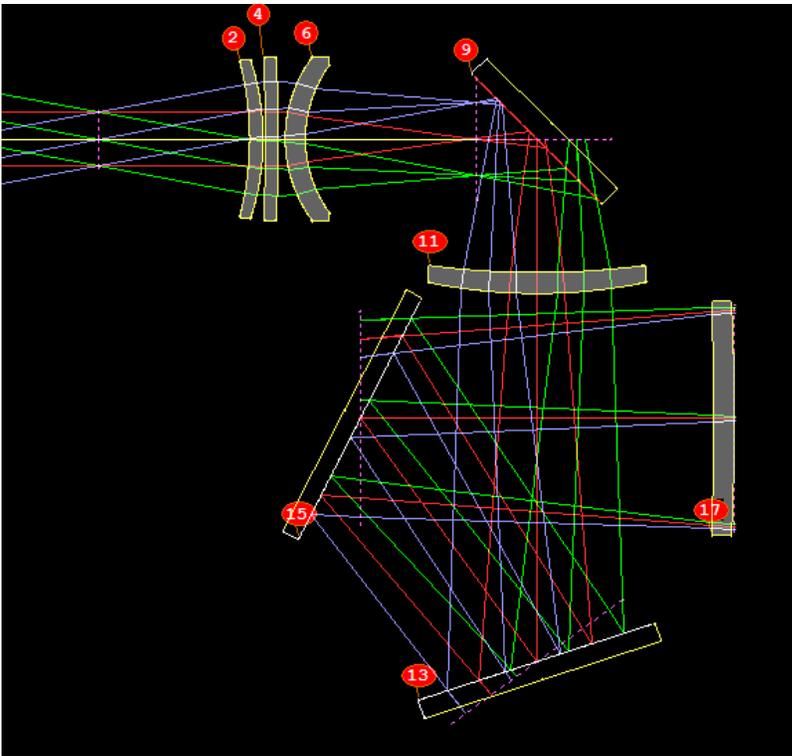
```

“Local” means the data are in the coordinate system (CS) of the previous surface, number 4 in this case. If you select the **Global** option, you refer to the CS of surface 1 instead. Those two options do not offer the automatic undo of the Relative option, but you can declare another surface coincident with an earlier one if that makes the job easier.

And if it doesn't, use the **Group** option. There you can specify tilts in three directions as well as a decenter -- and a group size, so the reverse TDC is automatic.



That's a lot of options -- but we're still not done. Here is a system with three fold mirrors. Now you have the option of describing each fold with a dummy surface following it (to tilt the axis an equal amount) or without the dummy, in which case the program *emulates* the effect of the dummy by assigning a negative UNDO to the following surface.



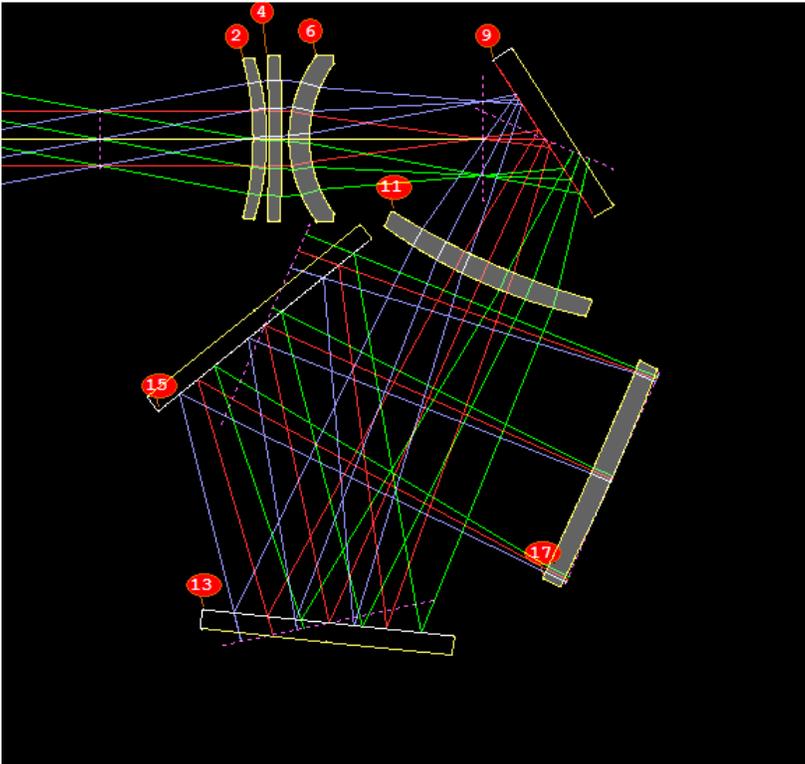
In the first case, we can describe the tilt on surface 9 with

**9 AT 45 0 100.**

Again, dialogs are only a click away if you don't yet know the format. This input gives a group size of 100, which is more than the number of surfaces in the lens, so the reverse tilt never happens. Surface 10 is a dummy, also assigned a 45-degree tilt. That's a simple protocol to use. If you assign surface 10 a pickup of the tilt on 9, then that surface is tilted and will follow along if the angle on 9 changes. The WS input in that case is simply

## 10 PAS 9 100

where **PAS** means Pickup ASymmetry. Now, if you click on surface 9 in WS, the topmost slider controls the tilt of that surface. Move the slider and watch the PAD display.



This is one way to make the optical axis follow a mirror tilt -- but it's not the only way. If you select the **Mirror Tilt** option, assign a tilt of 45 degrees, and remove the tilt of the dummy surface 10, you get the same effect -- only now you don't even need that dummy. Friendly.

Let us close this lesson with a horror story. A true one. SYNOPSIS has a feature that can find the optimum clocking of elements with measured wedge errors. Lenses are never perfect, after all, and every element has some residual wedge angle, even though it should not. But if those elements are aligned in the lens cell with just the right rotation about the optical axis, the ill effects of each wedge angle are largely cancelled out by the others. This feature is called **UCLOCK**, and you can read about it in the manual. The point here is that when you model all those wedges on all the elements, and then rotate each element in the cell, which is what UCLOCK does, you have a great many tilts all over the place. Every lens has an alpha tilt on one side and a gamma tilt on the other, with different group sizes. Imagine inserting dummies everywhere and trying to figure out the nested reverse tilts! The horror began when a SYNOPSIS customer sent those data to a Zemax user, who wanted to duplicate that model. But with all the crummy dummy surfaces needed by that program, he worked for a long time and eventually gave up. It was too complicated.

But not for SYNOPSIS.

This lesson should make it clear that crummy dummy surfaces are a relic of the primitive past. SYNOPSIS offers more friendly options than any other optics code.

Oh, we almost forgot: You also have the option of listing surface locations or ray coordinates in any desired **External CS**. See the ray path in the coordinates of the telescope pier. Powerful.